THE TELEGRAPHIC JOURNAL.

VOL. II.—NO. 21.

"THE GREAT PEACE-MAKER." *

THE notice of a poetical work in a scientific periodical may appear out of place. Yet it should not be so. A country's songs, we are told, are a record of the country's progress. This aphorism, true of a country, should be equally true of science; generalisation in either case has unbounded scope. Further, that the triumphs of a science should be recorded in a country's song affords strong proof, not only of the benefits derived individually by that country, but that the science has attained its noble end, and benefited mankind at large. As such a proof, Mr. Horne's poem, "The Great Peace-Maker," will be welcomed by the whole of the telegraphic profession. That the author of "Orion," one of the finest epic poems to which our language has lent its aid,—of the inimitable tragedy of the "Death of Marlowe," should have taken lyre in hand to sing the praises of the telegraph, is, indeed, a matter for our self-congratulation.

Too often is the progress or utility of science judged of by the rise and fall of stock and share. Even if science had no nobler end than being a means of pecuniarily enriching a nation, the judgment so founded must be a false one or be belied in the long long list of experimental failure. The experimentalist who relied upon science alone to remunerate his anxieties and failures could tell us of the frailty of such a judgment. Whoever can read may for himself learn of the riches shunned and honours declined by our greatest scientists. The cry of *Cui bono* has hitherto thinned the ranks of original research; it is time the aims of science should be painted in true colour.

There are few poems in our language comparable with this of Mr. Horne's,—few that deal so particularly with one science. The ancient Sanscrit poets sang of their mysteries of air and fire, which mysteries were then their science particularised; but their songs were chiefly from the uncontrolled imagination, and dwelt upon what might be, and were not poems in praise of what had been done.

But the relation between poetry and science has been described by abler literary pens than can be wielded here. We would seek only to acknowledge, with due deference, the recognition offered by the sister art of literature to her sister of science. It is from the sister art we have the idea of girdling "round about the earth in forty minutes;" it is now the consummation that is recorded in these words:—

"I am the instrument of man's desire
To hold communion with his fellow man,
In distant fields—in other climes afar—
Swifter than flight of migratory bird—
Nay, swift almost as speech from mouth to mouth."

Such is the answer of the Telegraph, in Mr. Horne's poem, to the question of the Sea:—

* * * "A Shape unknown
Moves through my lowest depths. Say, What art thou?

The Telegraph continues—

"Slow are his ships, O Sea, when wind and sail
Propel, and e'en the engines that surpass
All sails, are tedious when compared with me.
Thou measurest not thy being by its time;
But men are children of a varying span;
Their life is made of years, their years of days,
And every day to them built up of hours,
Which gives them all the hold they have on earth
To do and suffer."

The Sea— "'Tis their destiny
"Seek not by science to disturb the law
Which framed humanity, and meted out
Its time and space. Return, and climb the

The Telegraph—
"But science also is man's destiny—
Whereby 'tis granted to his working brain,
His industry, his patience and resolve,
To change his old relations with the law
Of space and time; henceforth dependent made
On man's advance in knowledge, and the power
Of *using* knowledge."

In the preface by Mr. Buxton Forman, we learn that a portion of this poem appeared in *Household Words*, and was written to commemorate the laying of the first successful submarine cable, between Dover and Calais, in 1851. It is easy to endorse Mr. Forman's remark:—"We can scarcely now accustom ourselves to think that the network of wires enveloping the dry-land of the earth, and spreading its meshes along the sea-bottoms, has come to its present stupendous intricacy in so short a time,—that only twenty years ago it was daringly prophetic to utter such words as those designating the sea as—

"'The means
"Of thought-swift messengers beneath thy waves,
Till England whispers India in the ear,
America—north, south—from pole to pole—
And words of friendship may pass around the world
Between the dawn and noon.'"

ELECTRO-MAGNETS.

By COUNT DU MONCEL.

IN my last note to the Academy of Sciences of Paris, I laid down a very simple formula, by which the diameter to be given to the core of a soft iron electro-magnet may be determined, that shall secure the best possible conditions in relation to the electromotive force and resistance of a given circuit. This formula, which leads implicitly to the conclusion that, in the case where an electro-magnet is established under all maximum conditions, the diameter is independent of the resistance of the circuit, and proportional to the $\frac{2}{3}$-power of the electromotive force, only with relation to an electromotor, of which the wire is of the same diameter as that of the circuit. But this is not a general case, and it was desirable that the formula should extend to circuits composed of conductors different, whether in nature or in size. This part of the problem is that which I solve to-day.

We have seen that, in order to obtain the value c, that is to say, of the diameter of the iron of the electro-magnet, I took Müller's law, formulated by the equation.

$$\frac{\mathrm{I}t}{\mathrm{I}'t'}=\frac{\sqrt{c^3}}{\sqrt{c'^3}}$$

c and c' representing the diameters of two electro-magnets, of which one, c', is the standard (*type de comparison*), which we suppose placed under convenient conditions; I and I′ are the current intensities; t t' the number of turns of spirals of the two helices.

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* "The Great Peace-Maker." A Sub-Marine Dialogue. By R. H. Horne, author of "Orion," the tragedies of "Cosmo de Medici," "Gregory VII.," "The Death of Marlowe," the mystery play of "Judas Iscariot," "Ballad-Romances," &c. London: Sampson, Low, and Co.

We have seen further, that in order to obtain the values of t and t' in functions of known quantities, I have had recourse to the formulæ derived from the conditions of maximum of electro-magnets, with relation to their magnetising bobbin, which give—

$$t=\frac{mc^2}{g^2},\quad R=\frac{2\pi c^3 m}{g^2},\quad I=\frac{E}{R+\frac{2\pi c^3 m}{g^2}}$$

m representing the coefficient by which it is necessary to multiply the diameter c, in order to obtain the length of iron of the electro-magnet; g designating the diameter of the wire, covered with its insulating envelope; R, the resistance of the exterior, and E the total electro-motive force.* When the conductor of the exterior circuit is under the same conditions as the wire that constitutes the helix of the electro-magnet, R need not be reduced in function of g to furnish the value of t; but it is no longer the same if, the wire having an indeterminate diameter, R is expressed in units of resistance other than that which serves to measure the length of the wire. It then becomes necessary to reduce R in function of g, for at least the evaluation of t. Now, as this reduction has for its expresssion $\frac{qRg^2}{f^2}$ (q representing a length equal to 375000, when R is expressed in units of telegraph wire of 4 m.m. diameter, and f being the coefficient by which it is necessary to divide g, in order to obtain the wire deprived of its silk covering), we obtain for the value of t—

$$t=\frac{mc^2\sqrt{qR}}{\sqrt{f^2 2\pi c^3 m}}=\sqrt{c}\ \frac{\sqrt{R}}{f}\ \frac{m\sqrt{q}}{\sqrt{2\pi m}}.$$

The second part of the second member of this equation, being a constant, can be calculated with the known quantities resulting from the data furnished by the standard electro-magnet, and which are $\frac{\sqrt{c'^3}}{I't'}$; so that we arrive at the simple expression—

$$c=\frac{E}{f\sqrt{R}}\left(\frac{m\sqrt{c^3 q}}{2I't'\sqrt{2\pi m}}\right),$$

which may still be freed from the factor f, if we consider it as making for I′ t', that which it has made for I t, obtaining the equation—

$$c=c'\frac{E}{E'}\ \frac{\sqrt{R'}}{\sqrt{R}}\frac{f'}{f}.$$

But the quantity between parentheses of the second member of the preceding equation may be easily calculated; and, according to the conditions of the standard electro-magnet I have employed, it is equal to 0·0000288 when f does not figure in the formula, or to 0·00004394 when that quantity is there represented, which is unnecessary, since the ratio $\frac{f'}{f}$ is sensibly equal to 1.

There result from this formula several important consequences, which may be rendered thus:—

1. *For circuits of equal resistance, the diameters of an electro-magnet should be proportional to the electro-motive forces.*

2. *For equal electro-motive forces, these diameters should be in inverse ratio to the square root of the resistance of the exterior circuit, comprising the resistance of the battery.*

3. The value of these diameters (supposing that the resistance R of the exterior circuit be expressed in metrical units of telegraph wire of 4 m.m. diameter, and that the value of E be calculated upon the hypothesis that the electro-motive force of a Daniell element is represented by 5973) has for its expression—

$$c=\frac{E}{\sqrt{R}}0{\cdot}0000288\quad .\ .\ .\ .\quad \text{metres}$$

and the figures obtained represent a fraction of a metre.

4. In employing for the value of E the ratio of the given electro-motive force to that of a Daniell element taken as unit, the formula becomes—

$$c=\frac{E}{\sqrt{R}}0{\cdot}172175\quad .\ .\ .\ .\quad \text{metres}$$

and the value of R be always expressed in metric units of telegraph wire.

5. In reducing the values of E and R to the co-ordinate system of electric measures of the British Association, that is to say, to the *volt* or unit of electro-motive force which represents $\frac{9}{10}$ of the force of a Daniell element, and to the *ohm*, which is equivalent to 100 metres of telegraph wire of 4 m.m. diameter, the formula becomes—

$$c=\frac{E}{\sqrt{R}}0{\cdot}01957\quad .\ .\quad \text{metres,}$$

or, in estimating the diameter in *mils*., the English measure representing thousandths of an inch.

$$c=\frac{E}{\sqrt{R}}628{\cdot}223\ \textit{mils}$$

According to these formulæ, we can calculate that the diameter of an electro-magnet worked by a Bunsen element (medium size) on a circuit having no other resistance than that of the electro-magnet, should be—

$$c=\frac{1{\cdot}86}{\sqrt{57}}\ 0{\cdot}172175=0{\cdot}0424^{m\cdot};\ \text{or}$$

1 inch 674 mils.

Again, an electro-magnet interposed in a circuit of 118620 metres, and worked by a Daniell battery of 20 elements should have a diameter represented by—

$$c=\frac{20}{\sqrt{118620}}\ 0{\cdot}172175=0{\cdot}01^{m\cdot}$$

or taking English units,

$$c=\frac{\overset{\text{Volts.}}{21{\cdot}58}}{\sqrt{1186{\cdot}2}}\ 0{\cdot}015957=0{\cdot}01^{m\cdot}=393{\cdot}7\ \text{mils.}$$

The diameter c obtained, the total length of the two bobbins of the electro-magnet become, for the first, 51 centimetres, or 25½ centimetres for each of the branches; and, for the second, 12 centimetres, or 6 centimetres for each bobbin.

The size of the wire can, as I have already said,

"Comptes Rendus," vol. lxxxi., p. 1405

be deduced from the following equations, when *c* is determined.*

$$g = \sqrt{f\sqrt{\frac{c^3}{\mathrm{R}}}\;0{\cdot}00002106} \quad . \quad . \quad . \quad . \quad \text{metres,}$$

which gives, for the first electro-magnet, $g = 0{\cdot}04865^{m\cdot}$, comprising the insulating covering, and $0{\cdot}00336^{m\cdot}$ without this covering. The length of the wire is, with this diameter, $242{\cdot}8^{m\cdot}$, and this quantity, reduced in telegraph wire (by dividing by 6 and by multiplying by the ratio of the sections) gives 57 metres as the value of R. For the second electro-magnet, these values are $g = 0{\cdot}0002597$ with the insulating covering, and 0·0001583 without the covering, with a length of wire of $1116{\cdot}7^{m\cdot}$.

The attractive force of these two electro-magnets with distance of the armature of 1 m.m., and taking the force of the standard electro-magnet, which is 25 grammes for a circuit of 1186·20 metres, is, for the first 23·112 kilogrms, and for the second, 26·85 grms.; this at least is the force which results from the laws of Dub and Müller, represented by the formula—

$$\frac{\mathrm{F}}{\mathrm{F}'} = \frac{\mathrm{I}^2\ t^2\ c\ \frac{3}{2}}{\mathrm{I}'^2\ t'^2\ c'\ \frac{3}{2}}$$

These several formulæ show why the electro-magnets interposed on long circuits should be of small dimensions, wound with fine wire; and why, on the contrary, they should be large when the circuit is short.

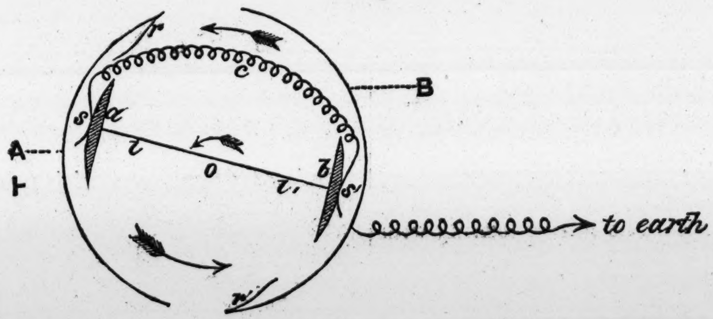
THE QUADRANT ELECTROMETER.

By JOHN MUNRO.

(Continued from page 2.)

The Replenisher.—The principle of the replenisher is that of statical induction, the name given to that property by which electricity on a body is enabled to draw forth electricity of an opposite kind to itself upon the nearest parts of any neighbouring conductor, and to drive electricity of the same kind as itself into the parts remote. Let A (Fig. 3) represent the trace of a curved brass plate positively electrified as denoted by the sign + and connected to the inner coating of the jar; B, another brass plate connected to earth, and so practically without electrification whatever. Between these brass plates, or "inductors," as they are called, a non-conducting arm, *l l'*, revolves round an axis, O, and fixed to each end of this arm is a small brass plate (*a b*) or "carrier." In the position shown the "carriers" are in contact with springs, *s s*, which place them, by means of a wire, *c*, in metallic connection with one another. While so connected, A induces negative electricity upon the near carrier *a*, and drives positive electricity to the remote carrier *b*. A moment after, as the arm revolves, the carriers—breaking contact with the springs—are insulated from one another, each, however, retaining its induced charge. Having revolved a little farther, the carrier *a* comes into contact with a spring, *v'*, which leads its negative charge to B, and thence to "earth;" while the carrier *b* delivers up its positive charge through another spring, *v*, to increase that already existing upon A and in the jar. If we look upon the charge induced upon *b* as being always a fixed percentage of the charge upon A, it will be seen that the charge upon the latter increases according to the compound interest law, and that a very small quantity of electricity on A, to begin with, very soon develops a large amount. The axis of the replenisher projects above the main cover, and it is turned easily by the finger.

FIG. 3.



The Gauge.—In order to indicate when the proper constant potential of the needle is reached, the instrument is provided with a "gauge." The principle of the gauge is the same as that of the new absolute electrometer, so that the gauge is an electrometer of the third class. It consists of two metallic discs, having their planes parallel and close to each other. The lowermost is in metallic connection with, and therefore takes the potential of, the jar which is to be gauged. The upper is to be perforated with a square hole immediately over the centre of the lower disc, and is connected to the outer coating of the jar. A light, thin, spade-shaped lever of aluminium is connected to, and held over, the upper disc, by a tense and twisted platinum wire, round which it moves as a fulcrum. The blade of this aluminium lever dips into the hole in the disc, and so nearly fills it up that, practically, the upper disc acts as if it were continuous throughout. To carry out the spade analogy in the case of the lever, the ring of the handle is represented by an opaque hair, and inside the handle there rises up a tiny pillar with two black spots enamelled on its face. This hair and pillar form the hand and dial of the gauge indicator; for, as the upper plate acts inductively on the lower, the electromotive force between them will always be an attraction whose intensity will be proportional to the potential of the jar. This attraction pulls the blade of the lever downwards against the torsion of the strained platinum wire which forms its fulcrum, while the hair at the other extremity of the lever moves up across the porcelain face of the dial. The torsion and tension of the fulcrum wire, and the distance between the upper and lower discs are so arranged that when the hair is midway between the black spots, the proper potential of the jar, and, consequently, of the needle, is attained. This adjustment is of a permanent description, although not necessarily so, and is done by the maker as a rule. The spots and hair are magnified to the observer by a plano-convex lens. In using the lines parallax must be guarded against by keeping the line of sight normal to the lens at its centre.

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* The coefficient of this formula is a little lower than that I have given (vol. lxxvii., p. 351, of *Comptes Rendus.*) This is owing to my expressing the ratio of the conductivities of iron and copper higher than it is practically, and that the diameter of the iron was below its true value.

Scale and Index.—The principle of reflection, so successfully applied by Weber to the galvanometer, is also adopted in the electrometer. A beam of light proceeding from a lamp placed behind the scale which stands in front of the electrometer, passes through an aperture placed below the graduated limb of the scale, and falling upon the mirror attached to the needle is reflected back upon the limb. The scale is engraved from a copper plate, and is distinctly graduated from 0 to 7·20 in single divisions, each one millimetre, and groups of five and ten. The scale and lamp are set to suit the focal distance of the mirror, which is usually about one metre.

The Induction Plate.—To increase the number of grades of sensibility, the electrometer is provided with an "induction plate" insulated directly over one of the rear quadrants. It consists of a thin brass plate, smaller in area than the top of the quadrant beneath it, and is supported from the main cover by a glass stem. It is provided with an electrode which is guarded by an ebonite jacket. This electrode projects above the main cover alongside of the lanthorn, and is fitted with a binding-screw at its head.

Action of Electric Forces on the Needle.—Let us now suppose that the quadrants are at one potential and symmetrically placed with respect to themselves, and that the needle is at rest and symmetrically placed with respect to them; then if we establish a difference of potential between one pair of quadrants and the other pair, the quadrants will enclose a field of electric force, and the needle will be caused to swing round its axis so as to take up a new position of equilibrium. Thus if (RR' Fig. 1) are electrified to a certain positive potential, and (LL' Fig. 1) connected to "earth" which has practically no potential; and if the charge of the needle is also positive, it will take up some new position in the direction of (PP'), for its blade *n* is acted upon by a force *f* repelling it from the quadrant (R), and its blade *n'* is acted on by an equal, parallel, and dissimilar force *f'* repelling it from the quadrant (R'). These two forces constitute a "couple" which turns the needle about centre. The mirror turning with the needle reflects the beam of light, impinging upon it from the lamp, a certain distance along the scale. This distance, measured in division of the scale used, measures the intensity of the electric forces, *f*, *f'*, and therefore the difference of potential between the quadrants.

Measurement of Small Difference of Potential by Quadrant Electrometer.—In using the quadrant electrometer to measure a small difference of potentials between two bodies, it is only necessary to connect one of the bodies to one electrode, and the other body to the other electrode, and the case of the instrument conjointly. Thus, to measure the difference of potentials between the poles of a Daniell cell, connect the two separate poles of the cell by a double key to the two separate electrodes, and also connect any one of the electrodes to the cover of the jar by means of one of the binding-screws on the cover. The "induction plate" may also be connected to the cover of the jar. "On putting down the key the image will be deflected over a number of scale divisions proportional to the difference of potentials to be measured, and on reversing the key an equal deflection should take place in the opposite direction."*

Measurement of Large Difference of Potential Grades of Diminished Power.—With the instruments as now made one Daniell cell by reversal readings gives about 100 scale divisions; and, in order to measure much greater difference of potentials, such as a telegraph battery, it becomes necessary to use the grades of diminished power. For all the grades "the different methods of forming the connections, with or without an inductor, are indicated in the following table, where R means the electrode of the pair of quadrants marked RR' in Fig. 1, L that of the pair LL', and I that of the induction-plate; C is the conductor led from one of the bodies experimented upon, O the conductor led from the other and connected to the outer metallic case of the instrument, which may be insulated from the table, if necessary, by placing a small block or cake of clean paraffin under each of the three feet on which the instrument stands; (R) or (L) means that the electrode of RR' or LL' is to be raised so as to be disconnected from its pair of quadrants. Thus, in the grade of diminished power or sensibility standing first in the table on the right, the electrode L is raised, one conductor is connected with R, I and the other with the case of the instrument. The grade standing last in the table in which L and R are both raised is the least sensitive of all.

Without Inductor.
Full Power.

$$\begin{bmatrix}\mathrm{L\,C}\\ \mathrm{R\,O}\end{bmatrix} \text{ or } \begin{bmatrix}\mathrm{R\,C}\\ \mathrm{L\,O}\end{bmatrix}$$

With Inductor.

$$\begin{bmatrix}\mathrm{L\,C}\\ \mathrm{R\,O}\end{bmatrix} \text{ or } \begin{bmatrix}\mathrm{R\,C}\\ \mathrm{L\,O}\end{bmatrix}$$

Diminished Power.

$$(\mathrm{L})\left[\begin{array}{r}\mathrm{RC}\\ \mathrm{O}\end{array}\right] \text{ or } (\mathrm{R})\left[\begin{array}{r}\mathrm{LC}\\ \mathrm{O}\end{array}\right]$$

Grades of Diminished Power.

$$(\mathrm{L})\left\{\begin{array}{c}\begin{bmatrix}\mathrm{R\,C}\\ \mathrm{I\,O}\end{bmatrix}\\ \left[\begin{array}{r}\mathrm{RIC}\\ \mathrm{O}\end{array}\right]\\ \begin{bmatrix}\mathrm{I\,C}\\ \mathrm{R\,O}\end{bmatrix}\end{array}\right. \text{ or } (\mathrm{R})\left\{\begin{array}{c}\begin{bmatrix}\mathrm{L\,C}\\ \mathrm{I\,O}\end{bmatrix}\\ \left[\begin{array}{r}\mathrm{LIC}\\ \mathrm{O}\end{array}\right]\\ \begin{bmatrix}\mathrm{I\,C}\\ \mathrm{L\,O}\end{bmatrix}\end{array}\right.$$

$$(\mathrm{RL})\left[\begin{array}{r}\mathrm{IC}\\ \mathrm{O}\end{array}\right]$$

Induced Charge on Raising Electrode.—If upon raising any one of the electrodes from the pair of quadrants beneath it, the light-spot on the scale should be deflected, it means that in the act a charge has been induced in that pair of quadrants. This charge must be led away to earth. For this purpose the quadrants LL' are provided with a dis-insulator, having a milled vulcanite head projecting above the "main cover." When this head is turned (by hand) till a small projecting pin in its side points to the word "contact" (C) engraved on the cover, the image will return to its proper place, and the milled head must then be turned to "disconnect" (D), so as to insulate the quadrants again. It will be seen that the electrode in contact with this pair of quadrants (LL') should, if possible, always be raised when it is necessary to use the less sensitive states of the instrument.

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* W. Leitch.

MATHEMATICS FOR NON-MATHEMATICIANS.

By W. PAGET HIGGS, LL.D., D.Sc.

DIVISION I.—THE ALGEBRA OF CONSTANT QUANTITIES.

(Continued from p. 6.)

Limit of Series.

THE powers of a quantity greater than unity increase without limit. Thus, there is no power of 2 but that the next higher power is greater. Improper fractions follow, of course, the same law; thus, $1\frac{1}{2}$ raised to the second power, or $1\frac{1}{2} \times 1\frac{1}{2}$, as it contains the half of one-and-a-half more than one-and-a-half, is greater than the first power. The powers of unity only never increase. But the powers of a proper fraction, or of a quantity less than unity, always decrease. Thus, the powers of $\frac{1}{2}$, viz., $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, &c., constantly diminish. Representing an integral quantity by x, and a fractional quantity by $\frac{1}{x}$, the powers of the first, or x, x^2, x^3, &c., continually increase, while the powers of $\frac{1}{x}$, viz., $\frac{1}{x^2}$, $\frac{1}{x^3}$, &c., diminish in value. Thus, with the series—

$$x \quad x^2 \quad x^3 \ldots . x^n, \text{ \&c.},$$

we have the following conditions:—

I. An increasing series, if x is greater than unity.
II. A decreasing series, if x is less than unity.
III. A series whose terms are all of the same value, when $x = 1$.

In the first and third cases, the sum of the series may evidently be made as great as we please by the addition of more terms. But where x is less than unity, this may or may not be possible.

If we take the decreasing series—

$$1 + \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8} + \tfrac{1}{16} + \tfrac{1}{32}, \text{ \&c.},$$

the sum of this series will constantly approach 2 in value, but will never attain that value. It will always be necessary to add the last term to obtain the value 2. Thus—

$$(1 + \tfrac{1}{2}) + \tfrac{1}{2} = 2.$$
$$(1 + \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8}) + \tfrac{1}{8} = 2.$$
$$(1 + \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8} + \tfrac{1}{16} + \tfrac{1}{32}) + \tfrac{1}{32} = 2.$$

2 is, then, the *limit* towards which the series—

$$1 + \tfrac{1}{2} + \tfrac{1}{4}, \text{ \&c.},$$

constantly approaches.*

Such a series as 1, r, r^2, $r^3 \ldots r^n$ has, then, *always* a limit when x is less than unity. The powers of r are constantly decreasing in value, and the higher the name of the power, the lower its value. Let n be a very distant term; $\frac{1-n}{1-r}$ will be the sum. But—

$$\frac{1-n}{1-r} = \frac{1}{1-r} - \frac{n}{1-r}$$

whence we see that the more distant is the term n (or, rather, the smaller the fraction $\frac{n}{1-r}$), the less is $\frac{1}{1-r}$ affected by the subtraction. $\frac{1}{1-r}$ is then the *limit* towards which the series $1 + r + r^2$, &c., approaches.

The formula given in our last section for the summation of an infinite series was—

$$\Sigma = \frac{a}{1-r},$$

where a is the first term. Substitute 1 for a, and we have as well by this method the expression—

$$\frac{1}{1-r} = 1 + r \ldots\ldots + r^n,$$

where $n = \infty$. Whence we perceive that "the sum of an infinite series is the limit toward which we approximate by continually adding more and more of its terms."

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* But we are not therefore to conclude that *every* decreasing series has a limit. It is possible to arrange a series (for instance, the reciprocals of the integer numbers in lots, each containing half as many terms as there are units in the denominator of its last term) having no limit.

ELECTRICITY AS AN ILLUMINATING POWER.

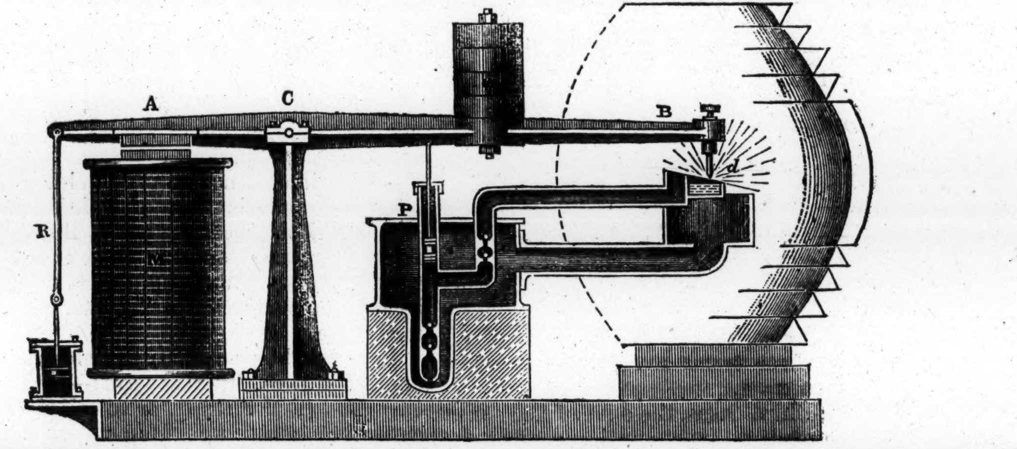
NOW that the problem of producing an economical source of electric light appears so nearly solved, it will not be uninteresting to revert for a moment to what was formerly done on this subject, and to admire the ingenuity of methods that may even yet meet with application.

The principal use to which electric illumination has been put, is that of lighthouses and coast signals. For street or house illumination it has failed from two causes:—the expensive nature of the sustaining power, and the fact that the electric light is too purely white and intense to be agreeable to the eye.

For lighthouse purposes, electricity has been applied in three different ways:—(1) Direct galvanic current. (2) Breaking, or so called *extra* galvanic current; and (3) Magneto-electric current. Numerous propositions have been made to use the direct galvanic current at different times, and a brilliant light has been produced; but there are great objections to the employment of electricity generated by galvanic batteries on a large scale for purposes of illumination—(1) from the difficulty and expense of keeping up the necessary provision for large batteries; and (2) the offensive gases which are set free in the chemical process, which takes place when the cells are in action. These are serious practical objections, and even were they reducible to an extent sufficient to enable them to be disregarded, the source of the current in the galvanic way is much too unsteady and varying to render it applicable to lighthouse illumination.

The second kind of light-apparatus, that based upon the *extra* current, was invented by Dr. C. W. Siemens, of London, for producing a flashing light signal on buoys and beacons. In his arrangement of the apparatus the light is placed upon the beacon, and connected with a galvanic battery on shore by means of a submarine cable. The apparatus on the beacon consists simply of a self-acting make-and-break (*trembleur*), the point of interruption being between a dish of mercury and a platinum contact, and conveniently placed for the observation of the flash due to the extra current. It is arranged as follows:—The beam A B, Fig. 1, turning on the axis, C, is held depressed upon the right hand side when at rest by a weight, W. At A is an armature of soft iron immediately over the poles of a vertical electro-magnet, M. When a voltaic current passes through the coils, the armature is attracted, and lifts the weight, W, which is on the other side of the fulcrum. The other end, B, of the beam carries an insulated platinum contact, which, when the beam is depressed on that side, dips into a dish, *d*, containing mercury. The opposite end of the beam is attached by means of a connecting rod, R, with a piston moving in a cylinder containing oil to act as a cushion in preventing the concussion which would ensue from the sudden attraction of the armature to the poles, were no such arrangement introduced. Between the platinum contact and bearing of the beam is a force-pump, P, whose duty it is to keep up a constant stream of mercury through the dish, *d*, during the time the beam is oscillating. The electric circuit is made from the submarine cable to the coils of the electro-magnet, thence, by means of a wire, to the platinum contact.

FIG 1.



The mercury dish, *d*, in connection with the body of the apparatus, is to earth. When a current arrives from the shore it circulates in the coils of the electro-magnet, through the wire to the platinum contact, the mercury dish, and earth, back to the battery and shore. In passing through the coils of the electro-magnet, it magnetises the cores and attracts their armature, which approaches the poles and lifts thereby the platinum contact carried by the other end of the beam out of the mercury. The electric circuit is then interrupted, and the electro-magnets lose their magnetism. The moment this is the case, the armature, no longer attracted, falls off, allowing the platinum contact at the other end to plunge again into the mercury and re-close the circuit. Each time the circuit is closed in this way the armature is attracted, the platinum contact is raised out of the mercury; and, at the point of interruption, there appears a flash of intense light caused by the so-called extra current in the circuit. The source of power on land is a battery of 10 to 20 Bunsen cells.

Either the galvanic battery is connected permanently with the end of the submarine cable on shore, or by means of an interval apparatus, which closes the circuit of the cable with the battery at given intervals. This interval apparatus consists of two levers alternately lifted out of a cup of mercury in such a way as to make the one which falls in or comes out last move very quickly, to prevent the destructive effects due to the spark. These levers are moved by means of two eccentrics turned uniformly by a common clockwork. These eccentrics are formed conveniently for allowing one lever to make its up stroke slowly and its down suddenly, the other its up stroke suddenly and its down slowly, the strokes being timed so as to allow the ends of both levers to be dipped with their platinum contacts into the mercury-cup just before the second lever, with its sudden up stroke, is elevated. The first lever then follows slowly. In descending again, the second lever enters the mercury slowly; but the first follows it with a considerable velocity. The battery circuit is closed when both circuits are in the mercury, and interrupted when either or both are out of it.

The first application of magneto-electricity to the illumination of lighthouses was in 1857, when Professor Holmes set up his magneto-electric light, by order of the Trinity House, in the South Foreland Lighthouse. At this station the apparatus gave promising results, and was, in 1862, removed to and permanently established in the Dungeness Lighthouse. Previously to this date, the Dungeness light had been supplied by means of eighteen Argand lamps with paraboloidal reflectors. Subsequently Professor Holmes has omitted the commutator originally used for directing the currents in the same sense through the circuit, and allowed them to alternate in producing the light.

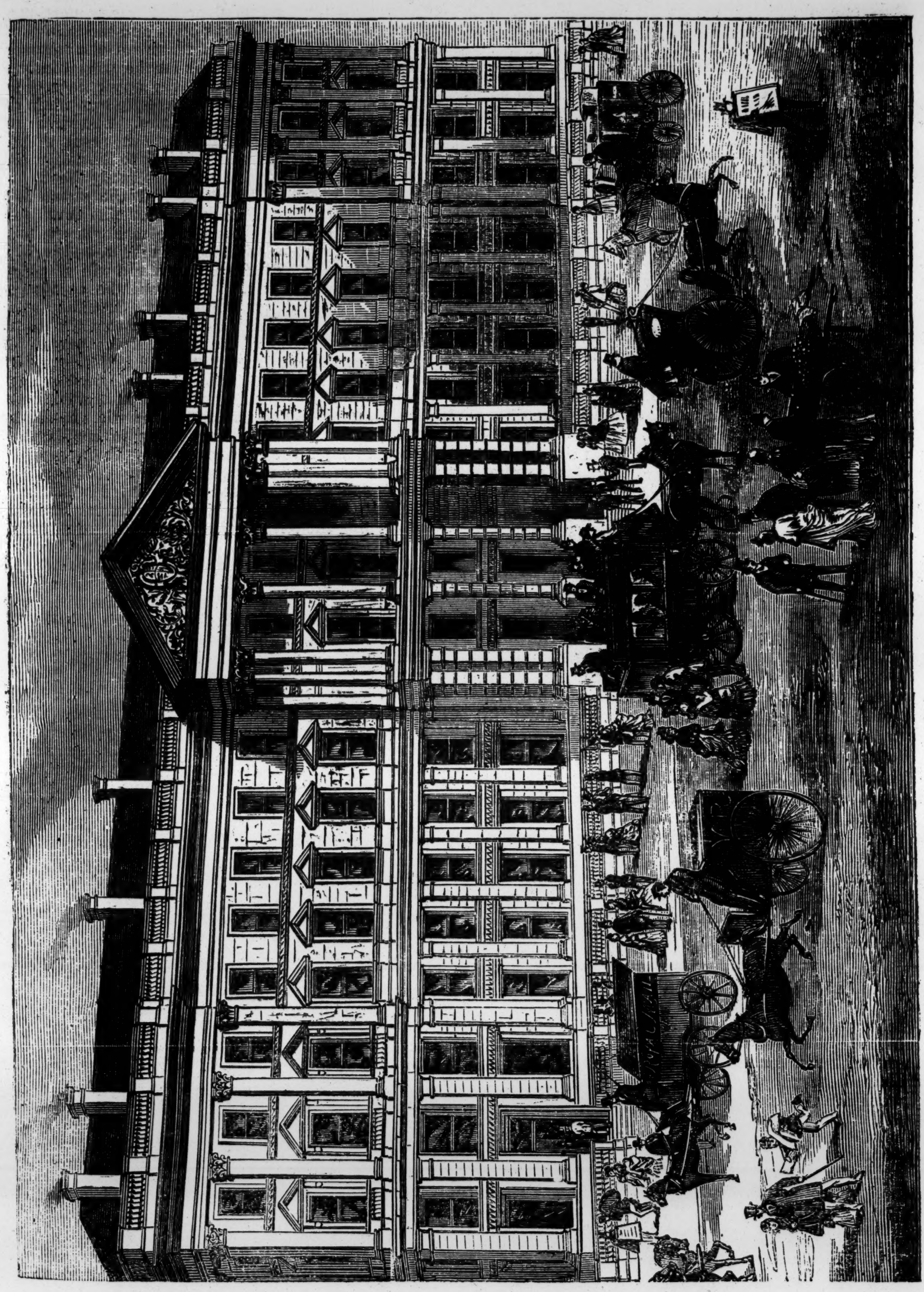
In the production of an electric light from any source, two points have to be attended to: (1) the intensity of the source of electricity must be sufficient to enable the current to overcome the resistance of the incandescent bridge between the charcoal points; and (2) the resistance of the whole circuit must be so small as to allow a considerable quantity of electricity to pass, in a given time, in order to give a sufficient *body* to the light. The first of these conditions, in a magneto-electric machine, depends directly upon the length of wire in the circuit, supposing it to be all equally profitably placed, and upon the quantity of magnetism developed by the permanent magnets.

The lamp formerly employed possessed equal movements for the two carbon points to accommodate the equal consumption caused by the reversed currents given from the apparatus. In principle it is the same as that made by Duboscq, and known as Foucault's regulator. It consists of two vertical rods, one of which supports the upper carbon point, and is weighted with lead; the other, supporting the lower carbon, is light, and is held up by a cord passing over an arbour which is set in motion by a second cord attached to the heavier rod. The cords being wound in opposite directions, the carbon points always simultaneously approach or recede from each other. The current is made to pass through the coils of an electro-magnet whose armature carries a paul catching between the teeth of a wheel connected with the arbour. When the light goes out, and the current ceases, the armature falls off, allows the wheel and arbour to turn, and the points to approach each other. The current re-established between the carbon points, the armature is again attracted, stopping the wheel in its further rotation, and, at the same time, pulling down a connecting rod upon which is the pulley of the cord, attached to the support of the lower carbon point. By this means this point is lowered about the eighth of an inch, enabling the incandescent bridge to be built up, and the light to be continued. The construction of this lamp is simpler than that shown by Duboscq, and is, therefore, better adapted for use in lighthouses. The lamp formerly used with the magneto-electric apparatus of the Compagnie l'Alliance is that known as Serruis's Regulator. It is constructed as follows:—The upper carbon is supported from a rod ending in a rack which gears into the the teeth of a wheel upon the barrel of a spiral spring. The rod supporting the lower carbon is held up by a cord passing round this barrel. The tooth wheel is also connected with a wheel work system, the last axis of which carries a radiating stop whose arms catch against the armature of an electro-magnet. The latter supports the tube in which the lower carbon is guided. When the current stops, therefore, the armature falls off, lifting up the lower carbon, and releasing the clockwork, which is turned round by the force of the spring until the carbon points are brought together again, the currrent again set up, and the armature attracted, by which the lower carbon point is pulled a little distance downwards. Of the other forms of apparatus we shall have occasion to speak presently.

THE NEW CENTRAL TELEGRAPH OFFICE.

As the great central Telegraph Office of the Kingdom, this magnificent edifice will afford not only ample accommodation for actual needs, but sufficient room should the telegraph service develope even to twice its present dimensions. The *Times*, a few days since, contained an interesting account, for the materials of which they acknowledge the courtesy of Mr. Scudamore. In our description of the building we shall avail ourselves of some of these particulars. The accompanying illustration will give our readers an idea of the handsome exterior, ornamented as it is with columns and cornices and mouldings in the renaissance style, executed in relief bold enough to break up the front effectively. The material used is granite as high as the ground floor, and above that Portland stone. The building is 300 feet long by 90 feet wide, and forms a parallelogram pierced with two central courts, which are the secret of the plentiful supply of light. The ground, first, and second floors are taken up by the different offices of the departmental staff, from the Postmaster-General's rooms downwards. The ledger room on the ground floor is of fine proportions, and very handsome with its pillars and mouldings of white stone, but the principal feature of the building is the great telegraph room, by far the largest in the world, occupying the whole of the upper floor. Its area is 20,000 square feet, and there are two-thirds of a mile of mahogany instrument tables. The wires are already laid from the main-lines into the room, which is at present a sort of electric siding to the telegraph system of the country. When all is ready the Telegraph-street wires will be cut, and the stream of messages turned into the new office. The countless ends of wires growing through the mahogany tables will each be connected with an instrument, and beside each instrument a card fixed in a stand will give the number of the "circuit." These will be as far as possible distributed geographically, Scotland and Ireland being in one corner together, so that the room will be a sort of telegraphic map. All the wires are gathered together at the "test-box," a neat array of "terminals." To these terminals the 440 wires are led from out of doors, and then on the instruments at the tables, the object of having all the wires together at one point in the building being to enable the engineer to alter the service as may be necessary. Each terminal being numbered, the route of the wire is known, and it can be used when wanted in making up a fresh circuit, or line of direct communication. Every evening the telegraph service of the country is altered for Press purposes, ordinary wires, no longer wanted for privated messages, being joined together to make lines of direct communication with towns in need of newspaper matter. There is, for instance, no direct communication with Darlington during the day, public messages being repeated from one place to another till they reach it. But at 6 o'clock the Darlington *Echo* begins to want its news, and the direct line or "circuit" necessary for the quick and economical transmission of the long Press messages is made up for the benefit of the *Echo* by joining a London and Sheffield, a Sheffield and Leeds, and a Leeds and Darlington wire. A Darlington and Newcastle wire is also joined on, so that the same information may at the same time reach another journal. When Mr. Bright delivered his recent speech at Birmingham a similar arrangement and diversion of wires enabled his speech to be telegraphed simultaneously by 12 automatic and 17 Morse instruments, one of the former being equal to two of the latter. Altogether, 150,000 words, or matter equivalent to more than 90 large print columns of *The Times*, was telegraphed from Birmingham that night between 9 p.m. and 2 a.m. The numbers on the brass finials of the test-box in the telegraph room of St. Martin's-le-Grand indicate the route as well as the destination of each wire. Thus Liverpool has in all no less than 17 wires, of which eight go by the London and North-Western Railway, six by the great Western, and three by the Grand Junction Canal. Of the thin green paper-tape, dotted with telegraphic strokes, no less than 10,000 miles a month are used throughout the kingdom, The colour is chosen as being less trying to the clerks' eyes. Even these 10,000 monthly miles of telegrams are not nearly all, for they do not represent the messages of the sight and sound instruments, of which there are 6000 in use, as against 1500 automatic or recording instruments.

All along one side of the great telegraph room are ranged the curved leaden tubes and brass fittings of the pneumatic delivery apparatus. Eighteen miles length of this pneumatic tubing are laid to twenty-five telegraph stations in the City and Westminster, which can thus deliver their telegrams at the Central office in parcel form faster than the messages could be sent by wire. The messages are enclosed, twelve or sixteen at a time, in despatch tubes, which are shot along the exhausted pipe to the counter of the Central office. From the counter they are carried to the check table, whence they are distributed, partly by messengers, and partly by travelling tapes, to the clerks at the instruments. The Post Office being the only collectors and distributors of messages, telegrams for the cables and lines of private companies come to this Central office, and are sent thence to the offices of the companies by



NEW CENTRAL TELEGRAPH OFFICE.

pneumatic despatch. The 440 wires working directly from the telegraph room are in communication with upwards of 1000 stations. The battery-room on the basement will have 25,000 battery-cells, and here, again, the wires are collected together at a test-box studded with innumerable brass finials. There is 300 miles length of gutta-percha covered copper wire within the building.

Leaving the spacious and handsome instrument-room (the telegraphic workshop and executive are lodged on the same floor), we notice through the windows the great chimney rising from the boiler-house built in the floor of the South Court. Descending a staircase under a handsome skylight, we pass the departmental offices of the lower floors, and, turning along corridors, always well lighted, descend to the engine-house, on the floor of the North Court. Here there will be three engines of 50-horse power each for the pumping work of the pneumatic tubes, and two of 10-horse power to draw water from the well of 400 feet deep which is being sunk on the premises. This well will soon repay its cost, and even the 50-horse power engine in Telegraph Street spends close upon £600 a year in drink. The new offices will have cost altogether when complete about £450,000, of which £300,000 has been swallowed up by the site. We rejoice that the administration at the Post Office of so distinguished a man as Dr. Lyon Playfair commenced at the time of the opening of this the greatest telegraphic centre in the world.

Students' Column.

Resistances and their Measurements.—By H. R. Kempe.

II. When the resistance we have to measure is very high as compared with the resistance of the galvanometer and battery used for measuring, we may practically, especially when great accuracy of measurement is not required, in our equation—

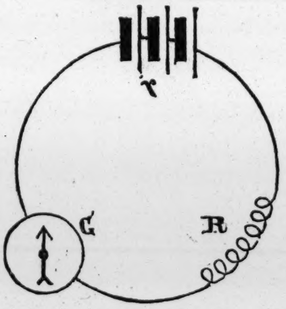
$$R = \frac{a_1^\circ}{a^\circ}(\rho + r + G) - (r + G).$$

put G as well as r equal to 0, in which case—

$$R = \frac{a_1^\circ}{a^\circ} \cdot \rho.$$

To measure a resistance, according to this formula, we should first join up our battery, galvanometer, and standard resistance, as it is called, which in our formula is ρ, as shown in Fig. 1; and having noted the deflection a_1°, we should multiply it by ρ, which gives us the *constant*.

Fig. 1.



R (the resistance to be determined) is then inserted in the place of ρ; a new deflection, a°, is then obtained, by which we divide the constant, and thus obtain R. This method of measuring resistances is the one generally employed in taking the daily tests for insulation resistance of telegraph lines, the standard resistance ρ being usually 1000 ohms.

When the insulation resistances of several lines are to be taken, the constant would first be taken and worked out, and the several lines to be measured being inserted in the place of ρ, the deflections are noted; and the constant being divided by the several deflections, the resistances are thus obtained.

For example—

With a battery, a galvanometer, and a resistance (ρ) of 1000 ohms in circuit, we obtained a deflection a_1° of 20°, then—

$$\text{Constant} = 1000 \times 20 = 20000.$$

Taking away our resistance and inserting—

Wire No. 1, we obtained a deflection of 5°
" " 2, " " 6°
" " 3, " " 12°
" " 4, " " 3°

The resistances of our wires are then—

No. 1, $2000 \div 5^\circ = 400$
" 2, $2000 \div 6^\circ = 333$
" 3, $2000 \div 12^\circ = 166$
" 4, $2000 \div 3^\circ = 666$

We should remark that the numbers here given as degrees are not really intended to be true degrees of deflection, but numbers which represent the strengths of current; for in no galvanometer are the strengths of current proportional to the true degrees of deflection which they produce, but are proportional to some function of those degrees, such as the tangent. Thus, if we were reading off the scale of degrees on a *tangent* galvanometer, that is to say, a galvanometer in which the strengths of current are directly proportional to the tangents of the angles of deflection which those currents produce, we should have to find the tangents of those degrees of deflection before multiplying and dividing.

For example—

If with a tangent galvanometer we obtained with our standard resistance of 1000 ohms a deflection of 20° (true), and with the unknown resistance (R) a deflection of 15° (true), we should have—

$$R = \frac{\tan 20^\circ \times 1000}{\tan 15^\circ} = \frac{\cdot 364 \times 1000}{\cdot 268} = 1358.$$

In future, when degrees are indicated, we shall mean true degrees.

When measuring the insulation resistance of a line of telegraph, that is to say, the resistance which the insulators offer to the escape of the current to the earth, having taken the constant, we should join up our instruments and line, as shown in Fig. 2. In making a measurement of this kind, it is usual to have the positive pole of the battery to earth, so that a negative (zinc) current flows out to the line, as a zinc current will show best any defective insulation in the line, a positive current having the effect, to a certain extent, of *sealing* a fault up, more especially if any underground work which may be in the circuit is defective.

The above method of measurement is, as a rule, sufficiently accurate for all practical purposes. Greater accuracy may, however, be obtained with but little extra trouble by allowing for the resistance of our battery and galvanometer in the following manner :—

Instead of multiplying the *constant* deflection by the 1000 ohms standard resistance, multiply it by 1000 plus the resistance of the galvanometer and battery, and having divided the result by the deflection obtained with the line wire in circuit, subtract from the result the resistance of the galvanometer and battery.

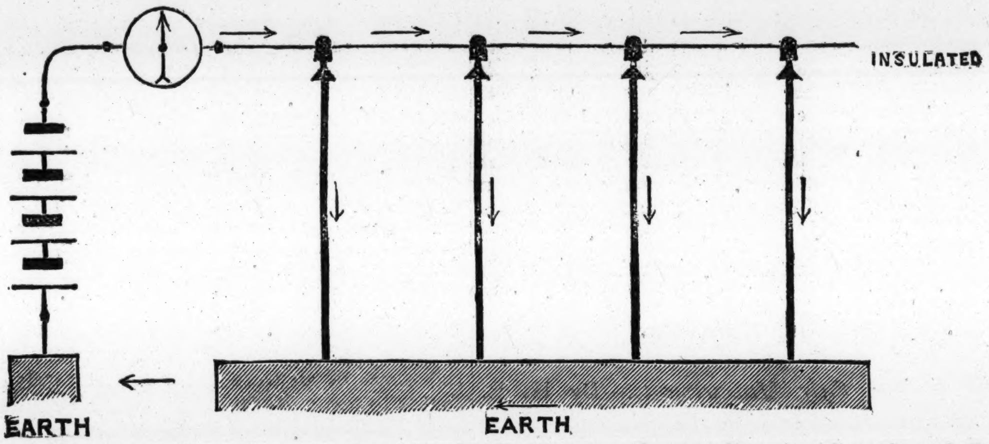
For example—

With a standard resistance of 1000 ohms, a tangent galvanometer of a resistance of 50 ohms, and a battery of a resistance of 100 ohms, we obtained a deflection of 30°, and with the line wire in circuit, for insulation resistance a deflection of 10°, to find the insulation resistance of the line—

$$\left.\begin{matrix}\text{Insulation}\\ \text{resistance}\end{matrix}\right\} = \frac{\tan 30^\circ(1000+50+100)}{\tan 10^\circ} - (50+100)$$

$$= \frac{577 \times 1150}{\cdot 176} - 150 = 3770 \text{ ohms.}$$

FIG. 2.



When a large number of wires have to be measured for insulation daily, it is very convenient to have a table constructed on the following plan:—

		α_1°			
		45°	44°	43°	- - - -
α°	1°	58823	56765	54824	- - - -
	2°	28571	27571	26628	- - - -
	3°	19230	18558	17923	- - - -
	⋮	⋮	⋮	⋮	⋮

In this table, the top row of degrees represent the deflections obtained with a tangent galvanometer through a standard resistance of 1000 ohms, the vertical column the deflections with the line wire in circuit. The numbers at the points of intersection of a vertical with a horizontal column are the resistances corresponding to those deflections calculated from the formula—

$$\text{Resistance} = \frac{\tan \alpha_1^\circ \times 1000}{\tan \alpha^\circ}.$$

Thus the *constant* deflection with the 1000 ohms standard resistance being 45°, and the deflection with the line wire being 2°, the resistance required we see at a glance to be 28571 ohms.

(To be continued).

ERRATUM (p. 9):—

For "a resistance (R) of 200 ohms a deflection (α°) of 20°, and with a resistance (ρ) of 350 ohms" read "a resistance (R) of 350 ohms a deflection (α°) of 20°, and with a resistance (ρ) of 200 ohms."

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

THE Annual General Meeting of this Society took place on Wednesday, the 10th inst.

The chair was taken by Mr. W. H. Preece.

The annual report was read by the CHAIRMAN. It stated that—

We have great cause for comfort and congratulation in the continued prosperous increase of the Society, and its rapid and constant growth. Although the increase is not so great as in the preceding year, it is nevertheless highly satisfactory; but it must be remembered that, as year succeeds year, the increase in the number of the Society's members must naturally decrease as we bring those of our profession within the folds of the Society. The total increase over the preceding year of members of all classes has been (including such gentlemen as will be balloted for this evening) 159; the total number of all classes at the present time being 512. The relative numbers at the annual meeting in 1872, and at the present time, are as follows:—

	1872.	1873.	Increase.
Honorary Members	0	3	3
Foreign	20	51	31
Ordinary	153	173	20
Associates	178	280	102
Students	2	5	3
	353	512	159

From these figures it will be seen that as the Society gets better known, so its scope is increased, the addition of Foreign members being highly promising; whilst at home a very large increase in Associates is apparent. We must not, however, forget, that whilst new members are constantly joining us, death has been busier with us than such a young Society can well afford. That well-known name—the father of Telegraphy—Sir Francis Ronalds, has passed from amongst us; his name was associated with Telegraphy from so old a date that he was the one link which bound the present to the past. We miss also M. Charles Lendi, of Berne, one of the original members of the Society, who was well-known in connection with the International Bureau. Sir Donald McLeod, Captain Langham Rokeby, Mr. George Saward, connected from its commencement with Atlantic Telegraph enterprise, and to whom Telegraphy to America must always owe a large meed of praise for his incessant exertions; and lastly Mr. Theiler, who, as a practical telegraphist, has long resided in this country.

The financial position of the Society is eminently satisfactory. From the present position of affairs, it appears that we have a balance in hand of over £500, exclusive of the value of the Journal, and of subscriptions overdue. The funds of the Society are largely indebted for their present flourishing condition to the liberality of two of our members—Mr. C. F. Tietgen and

Mr. H. C. Erichsen—who have each presented the Society with £100, in addition to their becoming life members. Such liberality is worthy of imitation by gentlemen belonging to the Society who are natives of this country. In addition to the above names, Professor Clark Maxwell has become a life member.

For some time past the Council, by means of their Sub-Committee, have been endeavouring to obtain rooms suitable for a library and office, which would be used as a council-room, and also a general reading-room for members. They have at length secured commodious and convenient rooms in No. 4, Broad Sanctuary, which are now being prepared ready for being taken possession of by the Society. They will be furnished as early as possible, and it is to be hoped that they will be opened early in January.

During the past year your Council have had the satisfaction of proposing the following distinguished names as the *first* Honorary Members of the Society:—Sir George Biddell Airy, K.C.B., Astronomer Royal; General Sir Edward Sabine, K.C.B., R.A.; Professor William Weber, F.R.S. The nominations were duly acknowledged, and the appointments accepted, and the Council have to congratulate the Society upon the fact that the Honorary Members first created are men of such eminence in science, and who have so greatly distinguished themselves in science and in pursuits which have had so material and so important a bearing upon the present successful state of telegraphy.

In order to cultivate our foreign relations, and to enable us to rise to the dignity of an International Institution, your Council have had under their consideration for some time the idea of a system of Corresponding Secretaries; they have, however, decided upon offering to eminent telegraph officials in Foreign States, and in our own colonies, an appointment, to be termed "Local Honorary Secretaries." For this purpose a communication was addressed to the several heads of departments.

Previously, however, the Council had elected the following gentlemen:—Colonel Robinson, R.E., Director-General of Indian Telegraphs, Honorary Secretary for India; Mr. W. E. Ayrton, Professor of Natural Philosophy, The College, Yokohama, Honorary Secretary for Japan.

Replies to the circular have been received, and the following subsequent appointments made:—M. D'Amico, Director-General of Telegraphs, Italy, Honorary Secretary for Italy; M. Nielsen, Director-General of Telegraphs, Norway, Honorary Secretary for Norway; M. Delarge, Inspector of Telegraphs, Honorary Secretary for Belgium.

The Council have every reason to hope that before long the various appointments for the different countries and states will be filled, and that the Society will benefit in a corresponding manner.

Certain alterations in the rules and regulations were considered advisable, and a sub-committee was appointed for the purpose; they have been subsequently brought before the meeting, after sundry alterations proposed and approved in Council. Of the alterations made, the following are the most important:—Rule 2. "Every member shall have been previously elected as an Associate;" these words have been left out so as to leave it within the discretion of the Council to elect a member direct, the double election having frequently proved an objection.

The amount of composition for Life Members has been reduced from twenty-five guineas to twenty-one pounds, and foreign members and associates are now allowed to compound for the sum of ten pounds. It is believed that this reduction will benefit the Society materially, so soon as it generally becomes known.

In addition to the above, clauses have been inserted respecting the funds and property of the Society, and the due regulation of the same.

Sundry other minor regulations have been altered, which your Council believes will materially contribute to the interests of the Society.

A *soirée* should have been held this year, but from the unfinished state of the new Post Office buildings, where it was intended to be held, was unavoidably postponed. The constant attention of Mr. Scudamore to the call of his country has unfortunately prevented him from attending to the duties of presiding over our meetings as often as he would wish to have done.

The Council have recently received from the Commissioners of the International Exhibition of 1874 the following letter:—

UPPER KENSINGTON GORE, LONDON, S.W.,
27th November, 1873.

"SIR,—The Committee for Class 14, Scientific Inventions, of the London International Exhibition of 1874, at their recent meeting, recommended Her Majesty's Commissioners to apply to the Society of Telegraph Engineers to exhibit in the class in question such novelties as may have lately come under their notice, or to advise the Committee how to obtain any such novelties for exhibition.

"I am, therefore, to express the hope that your Society will be willing to render Her Majesty's Commissioners the benefit of their valuable assistance in this matter.

"I have the honour to be, Sir,
"Your obedient servant,
"T. A. WRIGHT,
"Secretary for the International Exhibition."

The Secretary of the
Society of Telegraph Engineers,
2, Westminster Chambers, Victoria Street.

The Council appreciate the offer made, and consider it would be most important to the interests of the Society that they should be prominently represented amongst the class of inventors, &c., in the new Exhibition: they, therefore, consider it desirable that all the members of the Society should be written to in order that, should they have inventions or apparatus of any novel kind, they would undoubtedly add to the lustre of the Society by exhibiting under their auspices.

Of the Journal of the Society, two numbers have appeared already this year, the third number for this year is now in print, and will shortly be published.

The Council wish to bring before the members the importance of their contributing papers and communications to be read before the meetings of the Society on subjects connected with the science of electricity, and the practical progress of telegraphy. To a young Society the importance to be derived from the assistance of members in this respect cannot be over-rated. And those who attend to hear papers read, should bear in mind that so far as they are able, they, themselves, should contribute to the welfare of the Society by contributing such facts and experiences as come within their own personal knowledge. Great difficulty has been experienced in this respect. Members have been applied to personally, and the Council now have to appeal to them individually, to contribute for the interests of science generally, and telegraphy in particular, such papers as they can. In the course of next Session they propose issuing invitations for the contribution of papers on specific points. Ultimately, it is probable that as the finances of the Society improve, premiums will be offered for such contributions as are deserving of special merit. It may, however, be specially mentioned, that such papers as have already appeared in the journal read before our meetings have called forth special commendation, and have been much sought after.

In resigning his functions for the present year, the President has great gratification in announcing that Sir William Thomson has kindly consented, subject to your election, to become the President for the ensuing year, and it is anticipated that the presidency of a scientist and mathematician, celebrated over the world, will materially conduce to the interests of the Society.

Mr. M. GRAY moved a resolution expressive of the thanks of the society to the Institute of Civil Engineers for its generous aid in assisting the establishment and development of the society, and especially acknowledging the kindness of the institute for lending its beautiful and commodious hall, free of charge, for gas or any other item, for the meetings of the society. He said that there was no doubt that the fact of the meetings of the society being held in such an attractive room had done much towards aiding the progress which had been made by the society. The vote of thanks ought to be warm and hearty.

Mr. Walter Hancock seconded the resolution. He said that it would be in the recollection of many persons belonging to the society that, with the exception of the Society of Arts, the Institute of Civil Engineers was the only society which took any interest in telegraphy during its early stages. On these premises the institute had held many interesting discussions on the subject. It was, therefore, appropriate that the interest which the members of the institute had taken in the investigation and development of telegraphy should be continued in the present manner and in the same place.

The motion was carried unanimously.

That ballot for the appointment of a president and council for the ensuing year took place. The result of the election was as follows:—

President—Sir William Thomson, LL.D., F.R.S., Past Presidents—Charles Wm. Siemens, D.C.L., F.R.S., M. Inst. C.E.; Frank Ives Scudamore, C.B. Vice-Presidents—The Lord Lindsay; Latimer Clark, M. Inst. C.E.; R. S. Culley, M. Inst. C.E.; Professor G. C. Foster, F.R.S. Other Members of Council—Professor Abel, F.R.S.; Major Malcolm, R.E.; W. H. Preece, M. Inst. C.E.; Robert Sabine, C.E.; Carl Siemens, M. Inst. C.E.; Lt.-Colonel Stotherd, R.E.; Major Webber, R.E.; Wildman Whitehouse; Cromwell Fleetwood Varley, F.R.S., M. Inst, C.E.; C. E. Spagnoletti; C. V. Walker, F.R.S.; Professor Williamson, F.R.S. Associates—A. Bell; Dr. A. Muirhead; Lieut. Watson, R.E. Officers.—Auditors—J. Wagstaff Blundell; Frederick C. Danvers (India Office). Treasurer—Major Webber, R.E., 101, Cannon Street, E.C. Hon. Secretary—Major Frank Bolton. Hon. Solicitors—Messrs. Wilson, Bristows and Carpmael. Secretary—Geo. E. Preece.

Mr. Winter and Lieut. Ramsay acted as scrutineers of the ballot, and received the unanimous thanks of the meeting for their services.

An ordinary meeting of the Society was then held, when the discussion of Mr. G. E. Preece's Paper on

UNDERGROUND TELEGRAPHS

was resumed.

Mr. Andrew Bell, upon being asked by the chairman to re-open the discussion, said that the only experience which he had had in underground work, was acquired when such work was completely in its infancy, and scarcely anybody knew anything at all about it, and especially as to the joining of the wires. Many of the wires which were then laid had given way.

Major Webber said that there was one point in the paper which required explanation. He had failed to find that Mr. Preece had attended to one particular point which seemed to be essential in completing a satisfactory test of the cable of which he superintended the laying between Manchester and Liverpool. The author described, with great care, the mode in which he tested the joints of each section; but he did not describe the way in which he tested the joints between section and section, and he (Major Webber) did not see that the mode in which the joints of each section were tested was applicable to the testing of the joints between section and section. He might be wrong, but it seemed to him that some additional explanation was required, and that, for want of the tests of the joints between section and section, the cable was imperfectly tested. as all the joints from end to end were not completely tested. If Mr. Preece had made this omission, he presumed that he had made up for it in some other way. The society had to congratulate itself upon having elicited such an important practical paper as that of Mr. Preece. He (Major Webber) had had very little experience in the early stages of underground telegraphy, but he should like to be one of those who would bear witness to the very great perfection which it had reached of late years. He did not like the employment of an invisible conductor, except under the sea, but, unfortunately, it was necessary in this country to employ underground telegraphs. No doubt many persons were aware that the telegraph companies obtained legal powers by which they could lay down underground telegraphs almost anywhere they like, and that the employment of an overhead telegraph line could be adopted only with the sanction of the inhabitants of the locality in which it was proposed to erect it. Hence, in long lines from the country, underground telegraphs were often adopted when otherwise, as being the more expensive means, they would have been avoided. To this fact we might ascribe the development of underground telegraphs in this country. There was no doubt that if we travelled from one end of Europe to the other we should find that underground telegraphs were not used to anything like the extent to which they were used in this country. Unfortunately or otherwise, we were obliged to lay telegraphs underground in towns, while the atmospheric inconveniences would not compel us to do so. The reason of this was that overhead lines were supposed to be an eyesore in some localities. But on the continent of Europe, where the telegraphs were in the hands of more arbitrary governments, there was no such compulsion upon the administration. Hence, not only were overhead lines used in places where we should consider it essential to use underground lines, and where appearance would be a matter of moment, but they were used in watering places, and places of public resort, where the mere suggestion of an overhead telegraph would be in this country considered a barbarism. The development of underground telegraphy had been due to this anomalous state of things in this country. The immediate question which arose was: How are these underground telegraphs to be maintained in efficiency? We possessed the data according to which we could maintain a line of overhead telegraph in efficiency through a series of years. As the material of which it was constructed began to deteriorate, we could replace it without in any way interfering with the working of the line. In the process of maintenance, the localizing of faults was a very much more simple matter in the case of an overhead telegraph than in that of an underground line. But we lacked the data for the maintenance of underground lines, and for this reason the maintenance of the old underground lines was notorious for its inefficiency. A few years ago many underground lines broke down and became perfectly useless; and such lines even now, from day to day, broke down and became useless, from the fact that their maintenance had not been carried on upon a system which would counteract gradual and certain deterioration. This might particularly be observed in connection with some lines with which, no doubt, many were acquainted, and especially with regard to the joints; for, although the necessity of making good joints had been well known for many years past, there were many lines throughout the towns of this country in which the joints were scattered through at various places, sometimes at very short intervals, and were of such a nature that it was almost impossible to expect insulation. Mr. Preece's paper had described the construction of an underground line, which had been constructed in probably the most perfect way that any underground line had ever been made, and what should follow as a consequence to the paper, was suggestions in connection with the maintenance of those lines; for we know that an immense amount of money had been spent in lines of this description and which had been allowed to deteriorate, so that their life had scarcely been more than, if so much as, that of overhead lines. It was a great pity that lines of such an expensive nature should be put down, and that so little should be as yet suggested as to the best mode of maintaining them. We ought to know how long such a line as that described in the paper would last before it required to be renewed. Such knowledge might enable us to keep the expense of making an underground line from being greater than the necessities of the case required.

Mr. R. Gray said that he thought that the manner in which Mr. Preece took the tests of the joints was quite unnecessary, and it was very difficult when the two ends were not available. He thought the better way would be to do as was done at the final splice on board ship at sea, which was to test the joint with a given battery power by the ordinary per centage test for any time, and then afterwards submerge the joint in the trough, and take the test again. Any extra leakage over the first experiment would be caused by the joint leaking. This plan would meet Major Webber's view, as to the joints between section and section.

Mr. Walter Hancock said that he was exceedingly pleased with the paper that Mr. Preece had given, and with the immense care and skill which had been exercised, and the scientific appliances that had been used, in the manufacture and the laying of the particular cable which had been described. He had not had time to read the whole of the paper, but as a gentleman from Germany described at the last meeting the early stages of underground lines in that country, perhaps he (Mr. Hancock) might be allowed to make a few remarks upon the earliest stages of the use and manufacture of underground lines in England. Mr. Preece's paper said truly enough that all the various underground extensions started from about the year 1853; but he (Mr. Hancock) would give some information as to what was done in the earlier stages previously to that year. Shortly after Professor Faraday had told us that gutta-percha was a most useful and valuable dielectric, the Electric Telegraph Company began to turn their attention to the use of it for insulation. There were of course in a city like London many places where overhead telegraphs were much objected to, and it became very desirable indeed that subterranean telegraphs should be used. At about the end of 1846 or the beginning of 1847, Mr. Hitcher, who was at that time in the employ of the Electric Telegraph Company, applied to his (Mr. Hancock's) father to ask whether it was possible to turn gutta-percha to use in insulating wires. At that time one of the processes used for making round gutta-percha cores was to roll the material through two semicircular rollers; and the earlier specimens of gutta-percha covered wire were made about the middle of 1847 by rolling wires simultaneously with soft gutta-percha through a couple of rollers. One great objection to wires manfactured in that way was, that, at the junction of the two rollers the gutta-percha was generally open, and exposed the copper. Many other experiments were made from time to time, and at last, in the month of July, 1848, Mr. Hancock, senior, invented a machine which had ever since been used for the manufacture of gutta-percha covered wires for underground lines. It was a machine known as "*The* Gutta-Percha Covering Machine." It was rather remarkable that all the experiments that were made in connection with that machine were attempts to cover several wires in one core. This machine covered seven small wires enclosed in one core, of about 5-16 in. in diameter. In July, 1849, just about the time when the patent was specified, Mr. Reed, senior, whose name was very well known, was under a contract to lay a number of wires. His attention had been particularly directed to the use of subterranean wires, and he therefore applied to Mr. Hancock, senior, to know whether the latter could manufacture wires for him. It would, perhaps, be remembered that the first wires laid in the streets of London were three wires enclosed in one gutta-percha core. The wires were of copper, No. 16 gauge. The external cover was a core of solid gutta-percha, ½ in. in diameter. This form was found very useful occasionally; but at that time, and for some long time afterwards, it was customary to run the wires through the machine and lay on one coat only. It had never then been proposed to put two or more coats upon one wire. To this plan there were various objections—electrical, mechanical, and monetary. When a wire was covered with only one coat, a little flaw in one place practically ren-dered a long length of wire unusable. The mechanical objections were most serious. The art of coiling a cable into a circle always tended to make the wires assume a helical form, and to force them out of place. If they were coiled several successive times they became perfectly loose within the gutta-percha covering. The monetary objection was that there was a large amount of the covering material thrown away, and to remove this objection it was proposed to make the same core serve for four wires. The mechanical objection, however, still remained, and, indeed, was very much increased by this alteration. Shortly after this it was found that the cost and inconvenience of taking up all four wires, and throwing three out of use merely for the purpose of repairing one, were too great, and at length single wires began to be used. Double-covered wires were first used about the year 1850 or 1851. Mention was made at the last meeting of the early wires used on the continent. The early specimens of wire which he had seen on the continent were very indifferently covered. They had only a single covering, and, whether from a motive of economy, or the idea of gaining some greater electrical advantage, almost all the samples were covered with a mechanical mixture of flowers of sulphur and gutta-percha. That mixture would give, of course, a very good dielectric result, but in the course of a very short time, the sulphur tended to make the mixture very brittle. Another great objection was, that the sulphur coming in contact with the copper caused a sulphide of copper to be formed, and this ate away the wire. He believed that many of the failures that occurred on the continent in the subterranean telegraphs arose from the use of the sulphured gutta-percha. Many of the earlier wires failed because they were laid in wooden tanks. This was done, if he remembered rightly, from London Bridge down the South-eastern line. The wooden tanks were covered with crude tar. The crude tar contained so much naphtha that when the sun shone upon the tanks the tar ran upon the gutta-percha. The latter was then dissolved by the naphtha, and the wires in many cases ran together. One of the difficulties in connection with the maintenance of gutta-percha underground wires caused a great deal of trouble to the late Mr. Edward Highton, and after a most careful investigation he discovered that wherever such wires, unprotected, ran near an oak tree a peculiar fungus attached itself to the gutta-percha and promoted its rapid decay. The first submarine wire was laid in 1851 by the Submarine Telegraph Company. It was a single No. 16 wire, covered with only a single covering of gutta-percha to ½-inch diameter. That wire had a very short existence. It was laid simply to save the concession. The concession was granted for only one year, and one of its conditions was that a message should be taken across the Channel during the year. There was some difficulty in raising the money, as the risk was thought to be most extraordinary. This single wire was, therefore, laid that the condition might be fulfilled. It carried the message, and saved the concession for ten years. As a matter of curiosity he might state, that, one of the earliest proposals which were made for underground wires was made by Mr. Francis Wishart, the Secretary of the Society of Arts, and the suggestion was to make a solid core of gutta-percha, ½ in. in diameter, having four external grooves. A wire was to be laid in each groove, and the spaces were to be filled up with soft gutta-percha. This proposal was seriously made. It was at that time supposed that it would be impossible to place a covered wire in gutta-percha without a joint.

The discussion was again adjourned, and will be resumed at the first meeting in January.

VIENNA ACADEMY OF SCIENCES.

Dr. Steintz has communicated some interesting facts with regard to the changes in length and elasticity experienced by a metallic wire when traversed by a galvanic current. It has been disputed whether these changes are the same as those produced by heating without the galvanic current, or not. The author determined the temperature of the conducting wire from the fusion of a thin coating of stearine; while he raised to the same degree of temperature a non-galvanised wire surrounded by a system of tubes containing stearine in process of solidification. The coefficient of elasticity was determined by oscillations of tension; and change in length by an apparatus with two mirrors, indicating with precision thousandths of a millimetre. The result arrived at is, that the change in elasticity is the same in the wire simply heated as in the conducting wire; while the change in length presents marked differences. A wire about 53·5 m.m. long and 0·5 m.m. thick underwent, in a change of temperature of 37°, a change of length 0·040 to 0·60 m.m, or about 15 to 20 per cent. of that effected by simple heating. The expansion was the same in wires of brass, copper, platinum, and soft steel. Hard steel showed hardly any galvanic change. The elongating action does not take place suddenly on closure of the current, but progresses by degrees; and Dr. Steintz considers that the thermal vibrations arising from the galvanic current are polarised, and thus produces a more notable expansion than the ordinary thermal vibrations.

ZURICH SOCIETY OF NATURAL SCIENCE.

In the *Vierteljahrschrift* of this society Dr. Rudolf Wolf has recently published the thirty-third number of his *Astronomische Mittheiulngen*, in which he deals with the relation of sun spots to the variation of the magnetic needle. The author gives a series of daily observations of sun-spots, during 1872, made at Zurich, Peckeloh, Münster, Palermo, and Athens. The mean relative number obtained is, 101·7; and for the years 1866-72 inclusive, the series runs thus:—16·3, 7·3 (min. 1867), 37·3, 73·9, 139·1 (max. 1870), 111·2, 101·7. Dr. Wolf has constructed a formula by which the average yearly variations of magnetic declination, in a particular place, may be calculated from the relative sun-spot number (two constants for the place being given). In this way, for example, he obtains for Munich the quantity 10·80′ as representing the magnet variation for 1872; the number got from observation is 10·75′, showing a close agreement.

THE BATAVIAN SOCIETY OF EXPERIMENTAL PHILOSOPHY.

The following electrical subjects for prizes to be awarded in 1874 have been proposed by this Society:— 1. To determine what influence the pressure which is put upon an electrolyte has on electrolysis, and how far in this case is the principle of conservation of energy confirmed. It is wished that this inquiry bear on three liquids at least, to be chosen by the competitor. 2. To determine the resistance of the liquid amalgams of zinc and gold to the galvanic current. Six at least of each of these amalgams, in various proportions, ought to be examined. 3. A prize is proposed for new experiments which will enable a certain decision to be come to on the opinion advanced by M. Gaugain as probable, viz., that voltaic electricity is propagated by matter, while induced electricity is propagated by ether.

Obituary.

M. DE LA RIVE.

Upon his way to Cannes, staying at Marseilles, M. De la Rive died in the evening of Nov. 27, from the ultimate effects of an apopletic fit of a fortnight previously. In an able *mêmoire* of this distinguished man, the *Times* remarks that it is no doubt to his discoveries in the science of electricity that his great reputation is principally due. Scarcely more than half a century ago, electricity was comparatively in its infancy, occupying at most a chapter or two in the treatises of physics of that period. It has now become a vast science, and there are few of its branches to the advance of which De la Rive has not more or less contributed. His researches in 1825 and 1826 on the chemical theory of the voltaic battery, and on the properties of magneto-electric currents, prepared the way to future discoveries. Electro-dynamics, magnetism, the relations of magnetism with dynamic electricity, the propagation of electricity through the interior of bodies, the nature and properties of the voltaic arc, and the consideration of the various sources from which electricity is derived, are subjects which have all successively occupied his attention. At a later period, De la Rive directed his mind more particularly to the phenomena which accompany the passage of electric currents through extremely rarefied media. The results he obtained led him to a new theory on the cause of the aurora borealis; and, when this theory was contested by some, he demonstrated its plausibility by exhibiting before a select audience at Paris, composed principally of members of the Institute, a series of beautiful experiments, producing by artificial means the various principal phenomena which characterise the aurora. Besides these original researches, many of which we are obliged to omit, De la Rive published, between 1853 and 1858, a complete treatise on electricity and its recent wonderful applications, in three large octavo volumes, which, though not intended for a popular treatise, is comprehensible to all who have received a reasonable amount of scientific culture. This interesting work was immediately translated into English by Mr. C. V. Walker, F.R.S., and, both in France and in this country, is still considered as one of the most complete treatises on this branch of physical science. One of the most interesting of De la Rive's discoveries, and which soon became eminently practical, particularly in this country, appeared in a memoir published in 1840, in which he first brought to light the results he had obtained by applying the electric force in a direct manner to the gilding of silver and brass. De la Rive did not hesitate to make this discovery public, by communicating it at once to the Académie des Sciences, and thereby forfeiting all personal interest in its future application. His process, which was still imperfect for general use, was soon after taken up by Messrs. Elkington and Ruolz, and through their improvements rendered capable of replacing in a great degree mercurial gilding. It was on the occasion of this discovery that the great prize of 3000 frs. was awarded to De la Rive by the French Institute. He was selected by the Federal Council of Switzerland for an important mission to the English Government in the year 1860. During this visit, the University of Oxford conferred upon him the honorary degree of D.C.L. He was a Foreign Member of the Royal Society, and in 1864 he was nominated one of the eight Foreign Associates of the French Académie des Sciences.

Electrical Science in Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvii., No. 20.

Second Memoir upon the Method of the Intervention of Water in Chemical Actions, and upon the Relation Existing between Electro-Motive Force and Affinity.—By M. Becquerel.—*Resumé:*—1. The mixture of two neutral saline solutions, giving rise to a double decomposition, with or without precipitate, produces an uninterrupted series of hydrates, of acids, and of alkalies, by the intervention of which double decompositions are effected, and these do not disturb the equilibrium of the electric forces. 2. In the reaction of acid solutions upon alkaline solutions, hydrates are also produced, by the intervention of which is effected the combination of the acids with the alkalies, accompanied by the production of electro-motive forces; but in this case there is an excess of electro-motive force due to the direct reaction of the acid upon the alkali. 3. The determination of the electro-motive forces not only serves as a comparison of affinities as to their intensities, but to follow step by step (so to say) the variation in the dilution of the solutions with water. 4. In the reaction the one upon the other of an acid solution and an alkaline solution, containing the same number of equivalents of water, the electro-motive force is in nearly constant proportion with the resultant of a couple of which the solutions contain an equivalent of water more than the preceding, as the ratio of the electro-motive force of the couple SO_3,4HO and KO,4HO to that of the couple SO_3,5HO and KO,5HO is clearly equal to that of the couple $SO_3$5HO and KO,5HO and of the couple SO_3,6HO and KO,6HO . . .; since the ratio diminishes excessively slowly. This law appears to be general; we may, then, by means of a very simple empirical formula, find the electro-motive force of a determined couple of the series which is in relation to the affinity that produces this force.

On the Direction of Propagation of Electricity.—By M. Neyreneuf.—If we put into connection with earth one of the armatures of a Holtz machine, we obtain inverse effects according to the sign of the armature. If we touch the negative armature, the charge of the machine appears increased; if we touch the positive armature, the machine discharges itself. The difference is not so marked if we have attached the two jars *en cascade.* Admitted that electricity propagates itself in the direction from positive to negative (see *Comptes Rendus*, vol. lxxvi., pp. 1000 and 1351), if we furnish an easier route by touching the positive armature, it is clear that the inverse action of electrification of different parts of the machine cannot be effected. If it find two routes, as with the pair of jars, a derivation is produced of a kind which renders the machine continuous. The circuit of the current is only made greater when we establish the communication of the electrical armature with the earth, and consequently there is no reason for the machine to cease to work.

Poggendorff's Annalen der Physik und Chemie. No. 8.

Contributions to a Knowledge of the Magnetisation of Soft Iron.—By M. E. Riecke.—By *function of magnetisation* of an iron body is meant the quotient of the induced magnetic moment divided by the magnetising force. It varies in different bodies (for a determinate force) with their size and form, and nature of the iron; and in the same body, with the direction in which the magnetising force acts. In Poisson's theory, the function of magnetisation is determined experimentally for a certain body, and equations are given through which the functions for all other bodies may be deduced from this. Two functions of magnetisation, however, appear, in development of the theory. One is that of a ball of unit volume (call it p), the other that of an infinitely long cylinder, acted on by a constant magnetising force parallel to its axis (call this function k). Between p and k there is the simple relation, $k = \frac{p}{1 - \frac{4}{3}\pi p}$. The function k, which has exclusively occupied observers hitherto, M. Riecke here determines by a new method, having experimented with ellipsoids; he also used a wider range of magnetising forces than MM. Oberbeck and Stoleton. But he proceeds, further, to determine the function p; and it appears that within a very large range of magnetising forces, this has nearly a constant value for all kinds of iron, whereas the function k presents, in different pieces of iron, only a general similarity, and, in individual pieces, the greatest differences. The experiments are fully detailed. We may state that seven different ellipsoids were used, and the magnetising force varied from 8 to 40,000. The course of the function p shows that it grows with increasing force, attains a maximum between forces 20,000 and 30,000, after which it diminishes. The mean value of p is 0·02372, and the maximum value 0·2382. Viewing his results in relation to the molecular theory, M. Riecke points out that the molecular directive force which a ball of soft iron, of unit volume, exerts on a molecular magnet situated in it may be estimated at about 40,000.

On the Duration of Discharge of the Leyden Battery.—By M. P. Riess.—The quantity of electricity and the electric density of a battery may with ease be directly determined; not so the duration of discharge. For determining this, four methods have been tried, two of which, proceeding on the assumption that the luminous duration of the spark is synonymous with the duration of discharge of the battery, the author thinks liable to error, and requiring certain precautions and limitations. The first method he examines is that of measuring the length of sparks imaged in a rotating mirror, devised by Wheatstone, improved upon by Feddersen, who inserted water columns, of various lengths and thickness, in the circuit of discharge. He was fortunately led to this through the slow means of rotation he had, his mirror only making 40 revolutions in a second, whereas Wheatstone's made 800. Now it appears that the better conducting the circuit, the more metallic particles are torn from the electrodes by the passing spark; and these continuing to glow after the discharge prolong the luminous duration of the spark. The insertion of liquid conductors diminishes both the metallic dust in the spark and its glow. M. Riess enunciates the law that the duration of discharge of a battery with constant density is proportional to the quantity of electricity used, to which law Feddersen's results conform, where the water column was long enough to obviate the error just referred to. The second method the author examines is that of MM. Lucas and Cazin (lately described to the Paris Academy), in which a vertical disc of mica coated with collodion all except a series of short radial lines round the border, is quickly rotated, while a silvered glass disc with like radial lines, arranged vernier-wise to the first, being fixed beyond it, the spark beyond that is observed through these transparent lines. Reviewing the results got by these observers, M. Riess shows how, while they do not seem to conform to the above law, they may be made to do so, if *after-glow* is allowed for. (The micrometer balls consisted of zinc, which gives the longest duration of discharge. The order of some other metals used seems to show that the brightness of the spark does not merely depend on the quantity of dust given off, but on the nature of the metal). The author finds that the (proper) discharge-time of the spark, and the time of after-glow (which together make up the whole luminous duration), sometimes vary in the same direction, sometimes in opposite directions; and the former may remain constant, while the latter varies. It thus appears that the time of discharge of the Leyden battery and the luminous duration of the discharge-spark do not stand to each other in any fixed relation. A third method is that of the electric thermometer; the heating of a wire. M. Riess gives a hypothetical formula, which he finds confirmed by Feddersen's experiments and also by the fourth method here examined, viz., that of the electro-dynamometer of Weber. The use of this instrument for determining the duration of discharge depends on the fact that the deflection imparted to the movable wire coil in it is proportional to the square of the quantity of electricity which passes in unit time through each cross section of the coil, multiplied by the duration of passage. Thus, if i denote the quantity of electricity, z the duration of discharge, then the deflection ε of the coil (the observation being limited to a small angle, and A being a constant) is $\varepsilon = Ai^2 z$. To determine i it is generally sufficient to measure the quantity of electricity q which is accumulated in the battery, by means of the measuring-jar, and divide this quantity by z. The electro-dynamometer, in its present form, can only be used with battery-currents, which can be considerably weakened by the insertion of moist conductors in the circuit. If this limitation could be removed, we should have in the dynamometer and the electric thermometer (M. Riess considers) mutually supplementing and controlling means for easy and certain determination of the time of discharge of the battery.

On the Pulverisation of Electrodes in the Voltaic Arc.—By Dr. Hermann Herwig.—Grove, experimenting with zinc as positive, and platinum as negative, electrode, and estimating the quantity of oxygen consumed, arrived at the conclusion that the quantity of zinc pulverised is equivalent to the quantity of hydrogen simultaneously developed in a voltameter inserted in the circuit. Dr. Herwig thinks Grove overlooked the fact that, of the pulverised substance, part goes to the other electrode, while part is scattered about; his results only represent the latter. The author also preferred a more simple and direct method, viz., weighing and quantitative chemical analysis of the electrodes, after formation of the arc *in vacuo*. The loss of weight of an electrode during the experiment, plus the quantity of foreign metal which it has received, will express the quantity of pulverised substance. The metals used were iron, nickel, and copper; and in numerous experiments made thus, the effects, as compared with production of hydrogen in the voltameter, were quite irregular. Even where the same metal was used for both electrodes, some experiments showed a great waste of both, others more at the positive, others more at the negative. Dr. Herwig, however, found some objections to the experiments in which *both* electrodes were pulverised; he accordingly took for one electrode a large thick copper plate, and for the other a ball of quite pure silver (inoxidisable in air). By a suitable arrangement, the ball was brought over different parts of the plate successively, so that there could be no repeated action in silver that had once passed from ball to plate; also, no copper passed from the plate, the heat being more equally distributed. The quantity of pulverised silver which passed from the ball was easily found by simple weighing. From the tabulated results it is inferred, (1), that the loss of silver is not even distantly equivalent to the quantity of hydrogen developed; (2), that the balls undergo greater waste (other circumstances being the same) the oftener they have served for experiment, that is, the more their substance is loosened, and made suitable for the passing arc of light; (3), that the waste in longer experiments is more marked, *i.e.*, the higher temperature of the balls produces greater waste; (4), that the positive silver electrode suffers less waste where the opposite copper plate has an irregular surface; thus, some experiments were made with a plate, on which concentric grooves had been made with a lathe, the silver ball being frequently passed over these irregularities; (5), that the balls used as positive electrodes undergo the greater waste. It is thus not exclusively dependent on the chemical nature of the electrodes and the strength of current used how much pulverisation takes place, but on various other circumstances.

Relation between Capillary and Electric Phenomena.—M. G. Lippmann.—The author sets out from an experiment of Kühne's, which is this:—A drop of mercury is put in dilute sulphuric acid containing a little bichromate of potash. A polished iron wire is fixed in the neighbourhood, so as to dip in the acid and touch the mercury surface. Whenever it has touched, the drop is thrown into regular oscillations, which may continue for hours. The author explains this by the fact that the polarisation of the mercury drop with hydrogen (electrolytically) produces contraction in it, and the chromic acid has a depolarising effect. He brings a number of experiments to prove that the capillary constant (tension of surface, coefficient of Laplace's formula) at the contact surface of mercury and dilute sulphuric acid is a constant function of the electromotive force of polarisation at the same surface. On this principle he constructs a very sensitive capillary electrometer, also an electro-capillary motor. The latter is, briefly, as follows:—A trough filled with dilute sulphuric acid has two cylindrical vessels, containing some mercury, placed in it. Into the mercury, dip platinum wires connected with a Daniell battery, and protected from the sulphuric acid by glass tubes. Two bundles of narrow glass tubes (open at both ends), with a long glass rod in the middle of the bundle, float with their lower halves in the mercury of the two cylinders, the sulphuric acid filling their upper halves. It is the alternate up-and-down motion of these bundles that is aimed at, and this is effected by means of the galvanic current, which, passing through the platinum wires, alternately polarises the one mercury mass with hydrogen, the other with oxygen. In the one case, the capillary constant, the capillary depression in and between the tubes, is increased, and the bundle rises; in the other, the reverse occurs. This up-and-down motion is converted into circular by a simple arrangement of levers, &c.; a crank on the shaft works a key which reverses the currents. One of these machines went five days and nights with the same Daniell at a rate of 108 revolutions per minute; the speed falls off somewhat as the battery becomes exhausted. M. Lippmann further shows that the converse phenomenon, change of mechanical work into electrical, may be obtained if a galvanometer be substituted for the pile in the machine just described, and the wheel be turned. The galvanometer shows a current going through the dilute sulphuric acid from the enlarging electrode to the other, and the quantity of electricity is proportional to the increase of surface, but independent of its form. The author mentions some other interesting experiments in reference to polarisation by capillary force.

On a New Electric Machine on Holtz's Principle.—M. Leyser.—Reserved for illustrated translation.

The Writing-Ball.—The Emperor of Austria has just conferred the medal *Pro Literis et Artibus* on the inventor, Mr. Malling-Hansen, and on the manufacturer, Mr. Jurgensen, of Copenhagen, for the ingenuity and utility shown in the invention and manufacture of this useful instrument, which was exhibited at the Vienna Exhibition.

City and Commercial Notes.

We quote the following from Mr. Wm. Abbott's circular of December 5:—"With reference to the announcement which I recently make of an association being formed for the development of electric force, and its application to the many and varied channels of commercial and manufacturing industry, I am now pleased to state that the combination of men of science and business aptitude has been completed, and that an offshoot of this organisation will be shortly introduced to the public, having for its object the utilisation of electric light for docks, harbours, and large manufacturing establishments. The electric light will also be especially applicable to sea-going steamers, and its illuminating power being so intense, it may be said that by its use such deplorable losses as those of the Northfleet and the Ville du Havre will in future be rendered impossible.

The Eastern Telegraph Company's traffic receipts for the month of November, 1873, amounted to £35,096, against £33,667 in the corresponding period of 1872.

The Eastern Extension, &c., Telegraph Company, Limited, inform us that the receipts of their lines for the month ending November, 1873, amounted to £17,454, against £15,991 for the corresponding period of 1872 of the four separate lines, viz., British-India Extension, China Submarine, British-Australian, and Tasmanian Submarine Telegraph.

The total traffic receipts of the Great Northern Telegraph Company have been during November, 1873, 314,573 frs.; and in corresponding period of 1872, 229,187 frs. On the European lines—In 1873, 166,563 frs.; in 1872, 124,915. On the China and Japan lines—In 1873, 148,010 frs.; in 1872, 104,272 frs.

A special meeting of the Western and Brazilian Telegraph Company, Limited, is called for the 17th inst., with reference to the absorption of the Great Western Telegraph Company.

The receipts of the Submarine Telegraph Company for the month of November, 1873, amounted to £8851 19s. 8d.; for the corresponding month of last year they were £8485 2s.

The report of the Committee of Shareholders of the West India and Panama Telegraph Company, Limited, presented this day, embraces a narrative of the failures and shortcomings of the past, and recommends the formation of a new, Board. The Committee add that in the present position of affairs they do not think it desirable to consider the question of amalgamation with any other company, but that they are strongly of opinion that, as soon as their system of cables is placed in perfect order, negotiations may be advantageously opened. The steamships of the Telegraph Construction and Maintenance Company being on their way to make the necessary repairs and additions, it is believed "that the long-deferred hope of the completion of the system of the Company is now likely to be realised."

The Government Telegraphs and the Railways.—The *Pall Mall Gazette* of the 8th inst, quoting the *Western Morning News*, observes that an error of enormous magnitude has been discovered in the Government telegraph accounts. "Instead of purchasing, as was supposed, a freehold and absolute title, the Government finds that it purchased the leasehold only from the telegraph companies whose rights were bought up in many instances. The telegraph lines were leased from the railway companies, and what they sold was merely a lease of them. The railway companies are represented as being now engaged in "preparing their claims." Some of these, it appears, are uncomfortably large. The claim of the Lancashire and Yorkshire Railway for the telegraph line which the Government fondly imagined it had purchased from the Magnetic Company amounts, according to the *Western Morning News*, to £950,000. The matter is to be referred to two arbitrators—Mr. Weaver, secretary of one of the telegraph companies, on the part of the Government, and Sir John Hawkshaw, on the part of the Lancashire and Yorkshire Railway. Sir John Karslake is to be umpire." The approach of an arbitration of much public interest and importance which is thus alluded to can scarcely, however, be fairly called an error, nor is it possible that in purchasing the rights of the telegraph companies the Government imagined itself to be acquiring the whole of the privileges connected with telegraphs in the country. The Telegraph Act, 1868, after giving powers to purchase the undertakings of telegraph companies, goes on to recite that the railway companies on their part are either owners of telegraphs or they have contracts with telegraph companies whose apparatus is placed in the stations and along the railways and canals of the railway companies. Powers are, therefore, given in this Act of 1868 to the Postmaster-General to take the place of the telegraph companies in such contracts with the railway companies, and to pay the railway companies compensation, either to be agreed upon or fixed by arbitrators, for the loss of present and reversionary gains. The Lancashire and Yorkshire Company is mentioned by name in this Act as one of the railway companies with which arrangements will have to be made, and no agreement having been come to, although negotiations have been going on ever since the passing of the Act, the time has now come when a decision will have to be arrived at by arbitration, as provided in the Act, and before Sir John Karslake as umpire. Eminent counsel have been retained on both sides. The Marquis of Salisbury, as umpire, has already pronounced on a somewhat similar claim, involving, however, a much smaller amount than the sum to which on the part of the Lancashire and Yorkshire Company it will probably be contended that company is entitled. The Act of 1869 estimated £700,000 as a sufficient sum to cover the whole expenses of the Government in this part of the transfer of the telegraphs. The Lancashire and Yorkshire Company alone now demand a million or more. But it will be obvious that neither the Government nor the company is a fair judge in its own cause, and the public will look with interest for the decision of Sir John Karslake and his experienced assessors. The arbitration will involve difficult and intricate matters of account.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	Dec. 12.
Stock	Anglo-American (Limited)	100	85—86
10	Brazilian Submarine..	9	3¼—2¾ dis.
10	Cuba	All	8—8½
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	14	6—5 dis.
10	Eastern (Limited)	All	8⅝—8⅞
10	Do., New	All	..—..
10	Eastern Extn. Australia and China	All	8⅜—8⅝
10	Globe Telegraph and Trust	All	8—8¼
10	Do., 6 per cent Pref...	All	9⅜—9⅝
10	Great Northern	All	9½—10
25	Indo-European	All	16½—17½
10	Mediterranean Extension (Limited)	All	4¾—5¼
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	3½—2½ dis.
8	Reuter's..	All	10½—11
Stock	Submarine	100	235—245
1	Do., Scrip	All	2¼—2½
10	West India and Panama	All	5½—6
10	Do., 10 per cent Pref.	All	9½—10
20	Western and Brazilian (Limited) ..	All	12—13
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	91—93
10	Hooper's Telegraph Works	All	12¾—13¼
50	India-Rubber and Gutta Percha ..	All	27—29
Cert.	Submarine Cables Trust	100	109—112
12	Telegraph Construction	All	31—32
100	Ditto Ditto 7 per cent Bonds	All	102—105

Notes and Queries.

Electro-plating over Solder.

Cleanse from grease with caustic potash. Dip quickly in red nitrous acid, in order to remove oxide, and then wash away with water all traces of acid. Make a solution of mercury in cyanide of potassium; into this dip the joint for a short time; then wash in water as before. The silver may be then easily deposited upon the amalgamated surface.

True Courage.—Those who are in the habit of declaring, every month or so, that this is the age of selfishness, will find it difficult to reconcile their opinions with the actions of the men and women who, within the past six weeks, left comfortable homes and pleasant associations to do battle with the yellow fever and tend its victims in Shreveport and Memphis. . . . The Brotherhood of Telegraphers can pride itself on having produced some heroes, but we doubt if any were as worthy of the name as those noble fellows who fell, instrument in hand, at Shreveport. Mr. B. T. M. Jackson and Mr. Rae, the former an operator and the latter the Superintendent of the Western Union Telegraph Office, died at their posts, as did also Mr. Alfred Saville, the successor of Mr. Jackson. Mr. H. C. Davis, an operator of New Orleans, immediately volunteered to fill the gap made void by poor Saville's death, and Mr. William Bernard, an operator of Cincinnati, went forward with eagerness to bear him company. These two brave men have since, by order of Mr. President Orton, forwarded, free of cost, all despatches relating to the sufferers. Telegraph companies have often given us cause to be displeased with them, but this act of one of their number compensates for many defects. It is but right to say that operators went from Louisville and other cities whose names have not so far been published, although they are as highly to be commended as Messrs. Davis and Bernard.—*New York Times.*

Railway Brakes.—On Friday, Nov. 7th, a party of gentlemen connected with some of the principal railway companies went from St. Pancras to Bedford in order to witness the working of the Westinghouse or continuous air brake, which has now been for six months in constant use on one of the Midland trains. Both in going and also in returning on Saturday morning the party travelled by ordinary passenger train; so that no special or experimental stops could be made, and no time could be afforded for measuring the distance which the train ran, after the application of the brake, before it was brought to absolute rest. There was, in fact, nothing to be seen but the efficiency of the brake in causing the ordinary station stoppages, and thus tested, it accomplished all that has been claimed for it. On Saturday morning the rails were in the worst possible state, slippery from slight moisture; but the stoppages were made in periods of time varying from 15 to 40 seconds, according to the inclination of the road, and in distances that, measured only by the eye, seemed almost incredibly short. We understand that the Midland directors are at present contemplating the general introduction of the brake throughout their system, and that it is actually in course of being applied to all the trains of the Metropolitan District Railway. On the latter line the authorities expect to save the cost of the introduction of the brake in the first year of its use, by the diminished wear and tear of thefr station rails, which, on the present system of stopping, have a life seldom exceeding two years, as against an average of eight years for rails intermediate between stations. There is much reason to hope that companies may find it to their own interest, in many ways, to give the public the security against collisions which the air brake is calculated to afford. Among its other advantages, by allowing a train to run at full speed almost up to its stopping point, it saves all the loss of time incidental to slackening, and this, in a long journey with many stoppages, is much more considerable than would be supposed. Again, it absolutely prevents recoil of the train after stoppage, an occurrence which has been a fertile source of accidents to passengers, and of consequent litigation, and which explains the frequent discrepancies between the evidence of different witnesses on the question whether a train was at rest or not. The expedition will lead, we believe, to another of a purely experimental character, in a train devoted to the purpose, when the performances of the brake will be tested in every way that can be desired.—*Times.*

A "Duplex" Report.—

[From the annual report of President Orton to the stockholders of the Western Union Telegraph Co., July 13, 1869.]	[From the annual report of President Orton to the stockholders of the Western Union Telegraph Co., October 9, 1873.]
"The double transmitter—an apparatus for working both ways over one wire at the same time—has also long occupied a prominent place among speculative telegraphers, and has recently been extensively advertised by the promoters of various competing lines. During the past twenty years there have been several inventions for accomplishing this result, the first being that of Dr. Gintl, of Germany; but while it is *possible, under certain exceptional circumstances*, to transmit messages both ways at the same time, over one wire, *the conditions under which this result is obtained are such as to render the general use of the system impossible.*" "If there were, however, any practical value in this apparatus, its use—like that of the Morse telegraph—*is freely open to all.*"	"The purchase of the patents for the United States and Canada, of *this most important and valuable of all the improvements which have been made since the Morse telegraph was first established*, was mentioned in my last annual report. * * * We have now in operation over 100 sets, and it is the intention to have all our principal stations completely equipped with them as soon as they can be supplied from the factory." * * * * * "As our operators acquire experience in its use, the difficulties which attended it at first wholly disappear." * * "I confidently expect that, by the time the necessary instruments can be manufactured, *they will be largely introduced on railroad and other way wires.*" "Paid for patents on account of Stearn's Duplex, 19,258 dols."

Meetings of Societies.

Meteorological Society.—On Wednesday, the 17th inst., at 7 p.m., the following papers will be read:—Rogers Field, B.A., F.M.S., "On an Improved Form of Aneroid for Determining Heights, with a means of Adjusting the Altitude Scale for Various Temperatures." Capt. H. Toynbee, F.R.A.S., "On the Atlantic Hurricane of August 20 to 24, 1873." Staff-Commander C. George, R.N., "On a Mercurial Barometer for the use of Travellers, Filled by the Spiral-Cord Method."

To Correspondents.

PRIZES TO STUDENTS.

It has been decided to offer, from time to time, to our Students, prizes for the best and most carefully considered paper on a given subject. By the kindness and courtesy of Mr. Robert Sabine, C.E., who has placed the funds at our disposal, we are enabled to commence the series with a

Prize of £25,

to be awarded to the Author of the best paper on "The Evidence of the Theory of Correlation of Physical Forces as applied to Electricity and Magnetism," received by the Editor of this Journal on or before January 1st, 1874. Each paper submitted for competition must describe original experiments. Each paper to bear (on every leaf) some word or motto by which it may be recognised. The same word or motto to be inscribed on a sealed envelope containing real name and address of competitor. The papers not selected will be destroyed with the envelopes unopened. Papers to be addressed to the Editor, and endorsed "Students' Prize." The best papers will be selected, and submitted to a Committee of well-known Electrical Authorities (whose names will be published), who will award the prize for the most carefully prepared paper, irrespective of the view taken by its Author, whether favourable or unfavourable to the new theory. The award to be final. The Prize Paper to be printed in the columns of this Journal.

Erratum.—Column 1, line 9 from top, page 14, *for* 1859 *read* 1855.

A. R. Granville.—Zac's pile is usually quoted as an experiment in support of the contact theory; so are the remaining experiments you mention. They are too well known to need reproduction we think.